

DESIGNED TEXT AND SLLs' READING PROCESSES : AN EYE TRACKING STUDY

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DESIGNED TEXT AND SLLS' READING PROCESSES: AN EYE TRACKING STUDY

Ryan Lege

ABSTRACT

Typography is a seemingly small part of design that greatly influences the way people access a text to extract meaning. This paper reports the findings of a study designed to investigate the effects of typographical cueing and hierarchy on the reading patterns, recall, and comprehension of participants whose first language is not English. Participants were split into two groups: The control group was exposed to an 'undesigned' document, while the experimental group read a 'designed' version of the same document containing typographical hierarchy and cueing. Participants' reading process was measured by an eye tracking camera. Participants completed comprehension and recall questions post reading. The results show significant differences on recall and comprehension tasks, with the experimental group performing better than the control group. Eye tracking data also showed differences between the two groups with regard to fixations and reading patterns used on the texts.

INTRODUCTION

Language surrounds us and permeates our environment in many forms, both auditory and visual. Language, in its various forms and modes, is partially duplicitous in nature, "some things can be 'said' only visually, others only verbally" (Kress & van Leeuwen, 2006, p. 2). Extracting meaning from all forms of language, both auditory and visual, forms the basis for communication. The process of meaning making differs between verbal and visual communicative modes. For visual communication, the appearance of the medium itself plays a role shaping the messages communicated. Typography, "what communication looks like" (Felici, 2012, p. ix), is the aesthetics of communication must play a crucial role in

determining the messages derived from a text. Typography is to visual communication what register or phonology are to verbal communication. Candlin (2001) promotes typography as a “central part” and “key point of access to the rhetorics of a range of subjects” (p.1). Typography is the channel through which the meanings of a text are compiled and interpreted, implying that manipulation of “the design and layout of a printed page”, as Itkonen (2006) defines typography, can have major implications on how meaning is derived from a text. Typography also has an effect on our engagement with a text (p. 1). Lupton (2010) elucidates this idea further by providing insight into the process of typographical design;

“Designers provide ways into-and out of-the flood of words by breaking up text into pieces and offering shortcuts and alternate routes through masses of information...one of design's most humane functions is, in actuality, to help readers avoid reading (p. 87).”

There are many methods of designing type that can effectually enable typography to guide the reader through a text (see Beck, 1984; Foster 1979). Walker (2001) states “the role of a typographer [is to] articulate the meaning of a text, making it easy for readers to understand” (p. 3). A seemingly practical application for “shortcuts and alternate routes” that facilitate ease of understanding is education, and perhaps even more so, second language acquisition. Therefore, the question arises; how can typography be used best to expedite extracting meaning from a text? Samara (2004) remarks that “Like all things functional, typography is created at varying levels of quality” (p. 7). Could less designed texts hamper readers’ ability to extract the intended meaning and message from a text? This study aims to answer these questions using data derived from participants exposed to two

variations of text, both designed and undesigned, as well as comprehension measures, and state of the art eye-tracking.

LITERATURE REVIEW

TYPOGRAPHY AND READING

RATE, SIZE, AND LINE LENGTH

A number of studies and academic work delve into the influence of typography on reading speed. Most of these studies focus on four simple variables: Typeface, point size, spacing, and line length (Papadopoulou, Manoli, & Zifkou, 2014, p. 24). Beymer et. al (2008) investigated point size and typeface to ascertain the effects on reading speed and comprehension. They chose three different point sizes, as well as a serif and sans serif typeface as variables to investigate using eye tracking technology and a short comprehension quiz. Their participant group consisted of a wide range of age groups and both non-native and native-English speakers. They recorded a “slight reading speed advantage for larger fonts” with longer fixation periods on smaller fonts (p. 16). They did not find any statistical difference between the serif and sans-serif fonts. In addition, this study is one of the only studies that has employed eye tracking to study if having English as a first language makes a difference on the reading process. Their results indicate that the non-English first group read at a predictably slower rate, and re-read the text significantly more times. However, other than the time considerations, the non-English first group performed equally well on comprehension (p. 18).

Thiessen and Dyson (2010) conducted a similar study concentrated on type size and spacing, albeit with children as participants (N=6). The study exposed the children to 12 variations

of typesetting and measured ease of reading by rate and miscues. “Findings indicated that the performance of the children varied based on the size and spacing between the two groups” (p. 371). Specifically, the children performed better with the smaller sized texts.

In addition to font size, a number of studies have investigated line length (see Holst, 2010). In their review of literature, Dyson and Haselgrove (2001) note that “it is possible that line length may have a different effect on reading rate compared with comprehension” (p. 589). They also suggest that though there are complicating factors, there seems to be an optimal “medium line length” for maximum speed. They conclude that comprehension is dependent on reading speed. In summary, Dyson and Haselgrove indicate that line length can indeed affect rate, which in turn affects performance.

READABILITY AND LEGIBILITY

The ideas of readability and legibility are central attributes of a text that are influenced by typography. According to Williams, (2006) "Readability refers to whether an extended amount of text—such as an article, book, or annual report—is easy to read." A novel or short story would be examples of texts that need to be readable. "Legibility refers to whether a short burst of text—...a headline, catalog listing, or stop sign—is instantly recognizable." In our daily encounters with texts both in print and online, we may spend a large portion of our reading time scanning the text quickly. Legible text allows us to quickly pull relevant information from a text. As Lupton (2010) commented, “One of design’s most humane functions is, in actuality, to help readers avoid reading” (p. 87). Typography can enhance either the legibility or readability of a given text to better fulfill its role as a communicative medium.

There are numerous studies focusing on the readability and legibility of different typefaces. A perennial debate concerning the virtues of serif and non-serif typefaces is evident in the literature, with results favoring both sides. However, it is clear that distracting features of a typeface such as fancy serifs or strokes with high contrast can reduce readability (see Williams, 2006, p. 33).

TYPOGRAPHICAL CUEING

Researchers have conducted studies to see exactly which typographical features enhance either readability or legibility. The term typographical cueing is used to “generally refer to the use of typography (bold or italic type, or underlining) to signal the important ideas in a text.” (Waller, 1991, p. 245). Accordingly, typographical cueing focuses on the more granular details of type rather than the more holistic hierarchy of the entire document, which will be discussed later.

Papadopoulou et al. (2014) investigated some of these details including, “typographic features, such as letters’ expansion, letters’ weight, letters’ angularity, letters’ size and, to some extent, the letters’ slope, underlining, punctuation, especially question marks, exclamation points and quotation marks” (p. 34). Texts containing this rather extensive list of typographical features were presented to preschool age children. All the above typographical features were noticed by the children. Typography does indeed promote noticing, but this study did not investigate the effects of this noticing process.

Jourdenais et al. (1995) also focused on typographical cueing and noticing. They enhanced a text by highlighting preterit and imperfect verb forms. The treatment group’s productive language was found to contain more of the target structures (p. 183). Typographical cueing

in this case was found to have a direct impact on post-study language production. These results are in line with Coles and Fosters' (1975) observation that "people are more likely to remember cued ideas" (p. 106), but take it a bit further and show that cueing can extend its influence to language production.

Cueing can also alter the way readers move through and interact with a text. Waller (1991) notes that "Anything about a text which is discernable to readers may affect their perception of the status of a document and consequently their expectations, critical stance, reading strategies, goals, and outcomes" (p. 344). Authors of a given text may desire a specific outcome following interaction with their text. Educators, for example, may desire to improve the recall and uptake of certain key information. Typographical cueing aids in fulfilling this desire, but how exactly is this accomplished? Is there an optimal amount of textual enhancement? Lorch et al. (1995) studied this by creating 3 different versions of a text with cueing ranging from none (the control group), light, and heavy. Results indicate that "Cued recall was better in the light condition than in the control or heavy conditions, which did not differ" (p. 51). Excessive use of cueing can normalize the cues, minimalizing their impact on retention. Lorch et al. found that target words that were capitalized, a rather simple cue and feature of the 'light' passage, slowed the reading process and increased participant's ability to recall the targets (p. 51).

EYE-TRACKING STUDIES

Research into typographical cueing shows how seemingly small features can influence and alter reading outcomes. However, measuring the effect of typography on the reading process is much more difficult than simply measuring the results. Reading is an intricate harmony of complex thought patterns and minute optical muscular movements. Our

understanding of this multifaceted process has been enhanced in recent years by the advent of eye-tracking technology. This technology allows us to track the complex patterns of eye movement. Many studies have been completed in the fields of psychology and linguistics, revealing the way our eyes move through text. For the purpose of this study, we'll examine eye tracking research's contribution to knowledge concerning how the nature of the text affects the reading process. Eye tracking can be used to investigate how a learner interprets and understands a given text (Siyanova-Chanturia, Conklin, & Schmitt, 2011).

Interpretation of a text is inherently subjective, including judgments based on the general appearance of the text. Rello & Marcos (2012) investigated readers' preferences for specific textual features and compared these with eye tracking data to ascertain if features actually were effective in drawing reader's attention. In summary, the researchers stated that, "Text customization has an impact on readability. At the same time, some textual layouts are preferred to others regarding reading comfort." (Rello & Marcos, 2012, p. 64). One feature that had an impact on readability was font size; the smallest size, 14pt, was the least preferred size, but increased the duration of fixation on the text. Line spacing was also found to influence the amount of fixations on a text.

Beymer et. al (2008) is one of few studies to research the effect of typeface, point size, and spacing using eye-tracking and participants with a first language other than English. Their study showed that participants whose first language was not English approached the text in a different manner, with more rereading, but achieved similar results on the comprehension measures (p. 18).

Furthermore, the words of a text themselves have been found to affect reading. Traxler and

Pickering (1996) used eye tracking to measure processing of plausible and implausible grammar structures and found that in improbable cases, the fixation time was considerably longer (p. 461). Bergstrom and Schall (2014), provide a concise summary of the features of written language that lead readers to fixate on or notice particular words. The type of word, content or function, and even word length influence reading patterns (see Carpenter & Just, 1983; Rayner & McConkie, 1976). While the words themselves are not typographically enhanced, these studies show how the application of the eye tracking can provide information on how even small textual details influence reading. In addition, there are more holistic textual features that influence reading, Bergstrom and Schall (2014) point out that the structure of text, including headings and subheadings, can influence reading patterns and fixations (p. 167).

TYPOGRAPHICAL HIERARCHY

Typography can be used to guide the reader through a text and increase the salience of essential information. One way in which this is accomplished is by establishing a hierarchy within the text. Depending on the language, text flows in various ways, punctuated by entrance and exit points into chunks of text. For example, English text flows right to left, top to bottom, generally with a number of breaks that signify idea units or groupings. Typical texts have an established hierarchy to guide the reader through a text. Lupton (2010) explains, “A typographic hierarchy expresses the organization of content, emphasizing some elements and subordinating others” (p. 132). This process of emphasis and subordination takes place using typographical cues such as headings, spacing, line length, and indentation. In addition, there are some guiding principles which help establish a clear hierarchy in a text. Williams’ (2006) four principles of good design, contrast, repetition, alignment, and proximity are a clear example of how good design establishes

clear hierarchical structures within a text. First, contrast, or “the most important visual attraction on a page”, allows portions of a text to stand out, such as bold headings, establishing areas of interest which become entrance points into the text. If these contrasting elements are repeated, we can create multiple entrance points with similar importance, which in turn “develops the organization and strengthens the unity” of the text. The principle of alignment is used to ensure that all elements are visually connected with others, creating logical reading paths for the reader. Finally, proximity is used to cluster, organize and group information (p. 13). Canning (2004) notes that considering design principles helps to “display the overall structure of the text by visibly segmenting the text into distinct sections” (p. 2). A text with a clear flow created by typographical hierarchy is easier for a reader to access.

RATIONALE AND RESEARCH QUESTIONS

Research indicates that typography can greatly influence reading and post-reading performance. Typographical cueing, line-spacing, typeface, point size, word choice, all influence the reading process in a myriad of ways. Due to the complex nature of texts and the reading process itself, it is necessary to conduct research into specific typographical enhancements to empirically assess their effect on reading. This study attempts to build on prior research by using two versions of text, one ‘undesigned’ and the other ‘designed’ with typographical cueing to increase the salience of important information. Rather than focus on typeface, point size, or line spacing, which are controlled, the researcher focused on the use of typographical cueing to establish a clear hierarchy of information. Using two versions of a text, an eye-tracking camera, and a post-reading quiz, the researcher focused on these research questions:

- 1 Does the inclusion of typographical cueing in a text lead to increased comprehension and recall of a text?
- 2 Which hierarchical or typeface related cues are most effective at drawing the attention of participants?
- 3 How do typographical cues influence the way participants access a text?

METHODOLOGY

PASSAGE

The researcher chose the topic of suprasegmentals for the test passage, due to students' unfamiliarity with the text and small likelihood of completing comprehension tasks based on prior knowledge. The text was also created to have enough key information to draw upon for recall tasks. The original version of the text was approximately 200 words in length. Following pilot testing, the length of the passage was reduced to 140 words to focus more on the important details. The typeface, Helvetica at 12 point size, was selected for two reasons: First, the ubiquity and familiarity of the typeface, especially for participants accustomed to smartphone use, and second, researchers have noted Helvetica's neutrality and lack of distraction (see Itkonen, 2006; Waller, 2011, p. 8). Leading (line spacing) was set at exactly 20 points. Line length was set at 157mm. All of the features above were used to create both the undesigned and designed passages. Both passages were not only identical lexically, but also the typeface, base point size, line length, and line spacing were controlled. See **Appendix A** for the baseline, undesigned passage.

The designed passage was then altered to include typographical and hierarchical cueing. First, hierarchy was created by increasing the point size of the title and headings. Cues were

added to increase the salience of important words. These cues included color, bold, italics, baseline shift, and size adjustments (but not altering the base point size). See **Appendix B** for the designed passage. There were a total of 21 changes made to the designed document. For eye tracking purposes, each of these changes was selected in the eye-tracking software as an Area of Interest (AOI). The corresponding areas in the undesigned document were also marked as AOIs so that comparative analysis could be undertaken.

PARTICIPANTS

Participants were selected from a pool of Japanese 2nd and 3rd year university students (N=65) majoring in English. All students were at an intermediate English level or above (TOEIC 480 or higher). None of the students had lived for a significant time (more than 6 months) outside of Japan. Their ages ranged from 19-21 years old.

PROCEDURE

Participants were randomly assigned to the control or experimental group. Participants were compensated at the student employee rate for their time. Participants completed the tasks individually one-by-one. First, participants were led into a quiet, controlled environment to a computer with an eye tracker attached. Participants read and signed an informed consent form in their native language of Japanese. They were then presented with a simple set of instructions, also in Japanese.

Participants were oriented in front of a monitor with a resolution of 1920x1080, set at 80% brightness. An eye tracking camera was set below the display. This eye tracker, The Eye Tribe Tracker from The Eye Tribe, features a sample rate of 30-60 Hz and accuracy of 0.5-1 degree. Participants were oriented in front of the tracker at a fixed distance. Participants

then completed a calibration process to ensure the tracker accurately measured eye movement. Following calibration, participants were presented with either the designed or undesigned text. The text was displayed for 70 seconds to encourage reading quickly, due to feedback from pilot testing. After reading the text, participants completed a set of comprehension and recall questions on the computer. These questions included both multiple choice and open-ended response items.

ANALYSIS

Eye-tracking data was compiled using the Eye Proof Suite of tools for research and analyzed using Sofa Stats statistical analysis software. The eye-tracking camera was unable to track several participant's eye movements, so these students' data was removed from the study. Data analysis was completed for 23 participants exposed to the designed passage and 22 participants exposed to the undesigned passage (N=45). Areas of Interest (AOI) were normalized according for size and analyzed to see the differences in fixation between the two versions of the passage.

Comprehension and recall items were assigned numerical values. Open-ended items were scored using a rubric. This data was also analyzed using Sofa Stats statistical analysis software. In addition, the AOI which contained the answers for each of the comprehension and recall questions was noted and analyzed for questions that received significantly different responses between the two groups.

RESULTS

EYE-TRACKING DATA

Analysis of the eye-tracking data

There was no significant difference for the average fixations on areas of interest, indicating that participants were attentive to, and actively tried to read their version of the document within the time frame.

Percent fixated is a measure of how many participants focused on a particular area of interest (AOI). The average value for percent of AOIs fixated was higher for the designed group (D) at 67.38% than the undesigned group (U) at 64.66% [$t = 0.193$, $df = 43$, $p = 0.8482$], though not significant. However, there were specific AOIs that showed greater variance between groups. Specifically, AOI 6, which was fixated by 100% of D group participants and only 62.07% [$t = 3.273$, $df = 43$, $p = 0.0021^*$]. Area 6 contained multiple typographical cues, including size, baseline shift, and boldness.

Other AOIs from the designed passage (D), 1, 8, 10, 11, 12, 13, 14, and 21 all were fixated in excess of 10% more than their undesigned counterparts, though these were not found to be significant. Interestingly enough, all of the above areas, with the exception of area 11, contained multiple typographical cues, e.g. color and size.

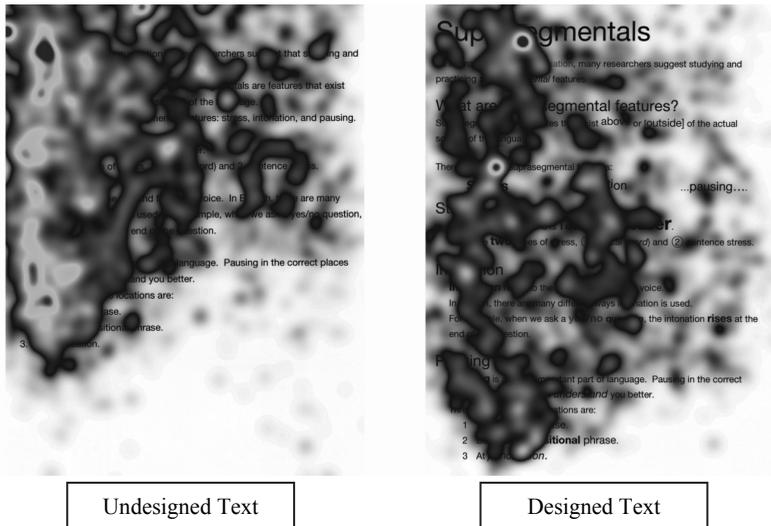
On the other hand, AOIs 4, 17, 19, 20 were fixated in the undesigned passage at a rate greater than 10% more than they were in the designed passage. AOI 4 occurred at the beginning of a line, and areas 19 and 20 were part of a list, which are both examples of simple typographical cues present in the undesigned text.

Averaged reading patterns showed both groups began the task by fixating on the center of the document, following which they quickly moved to the top of the page. The designed group focused more on the headings and large words, while the undesigned group seemed

to focus more on the beginning of each line text, relying on their knowledge of rhetoric to guide them through the text.

Figure 1

Comparison between heat maps for the designed and undesigned texts.



COMPREHENSION AND RECALL

Due to the normal nature of the data, with participants randomly chosen out of homogenous pool, a t-test was determined as the best statistical measure to determine differences between groups.

The total score, combining both the comprehension and recall items was analyzed using a t-test. The analysis showed significant difference between the two groups with regards to their performance on recall items.

Table 1

T- test of Total Comprehension Recall Scores

Group	N	Mean	SD	Min	Max	t
Designed	23	8.78	2.80	4.0	13.0	3.532
Undesigned	22	5.68	3.09	1	12.0	

$p < 0.001^*$

Degrees of Freedom (df): 43

An ANOVA was also performed on the total scores, to provide further information about the nature of variance between the two groups.

Table 2

ANOVA for Designed and Undesigned Groups

Source	SS	df	MS	F	p
Between	108.114	1	108.114	12.474	$< 0.001^*$
Within	372.686	43	8.667		

Similarly, the ANOVA indicated that there was indeed significant variance between the two groups.

Next, a t-test was performed on the total score for the multiple choice questions.

Table 3

T- test of Multiple Choice Questions

Group	N	Mean	SD	Min	Max	t
Designed	23	2.83	0.83	1	4.0	3.57
Undesigned	22	1.82	1.05	0	4.0	3.57

$p < 0.001^*$

Degrees of Freedom (df): 43

A significant difference was observed between the two groups, the designed group's scores higher than the undesigned group. Additionally, a t-test of participants' scores on the open-ended recall items showed similar results, albeit with a slightly higher p value

Table 4

T- test of Open-ended Questions

Group	N	Mean	SD	Min	Max	t
Designed	23	5.96	2.67	2	10.0	2.62
Undesigned	22	3.86	2.70	0	10.0	2.62

$p = 0.01223$

Degrees of Freedom (df): 43

Additional analysis, in the form of t-tests, was run for each individual item on the comprehension text, in an effort to isolate areas of interest linked to typographical cueing. Question 3, linked to Area of Interest 4, was found significant at a p value of 0.05 [$t = 1.974$, $df = 43$]. Area of Interest 4 contained a size adjustment and baseline shift. Question 5

reached a higher level of significance [$t = 3.287$, $df = 43$, $p = 0.002$] and was linked with AOI 5 and 6, cued by boldness, baseline shift, and size. Question 10 [$t = 2.996$, $df = 43$, $p = 0.004$] was linked with AOI 13, which was cued using size and baseline shift. All questions with significant differences were linked to AOI enhanced by size and baseline shift, although it cannot be concluded whether this relationship is causal or merely correlational.

DISCUSSION

RESEARCH QUESTIONS

- 1 Does the inclusion of typographical cueing in a text lead to increased comprehension and recall of a text?

Typographical cueing does seem to influence comprehension and recall of information from a text. However, as the comprehension test was taken directly following interaction with the text, this supports the findings of Coles and Foster (1975) that typographical cueing will lead people to remember cued ideas and improve immediate recall. The presence of multiple typographical cues in significant recall items suggests that noticeably visibly altered portions of text draw the attention of the reader and enhance recall ability.

- 2 Which hierarchical or typeface related cues are most effective at drawing the attention of participants?

Creating a hierarchy of importance from the title to the headings to the body text using contrasts in typeface size seem to have the largest influence on drawing the attention of participants. Furthermore, using baseline shift to interrupt the homogeneity of a line seems to draw attention.

3 How do typographical cues influence the way participants access a text?

Other than the reasons mentioned above, analyses of the eye tracking data indicate that texts featuring typographical cueing and hierarchy allow the reader to approach a text in different ways. Returning to words of Lupton (2010) concerning the nature of typography, “Designers provide ways into-and out-of-the flood of words by breaking up text into pieces and offering shortcuts and alternate routes through masses of information” (p. 87). By reinforcing the hierarchy of the text and inserting typographical cueing, the researcher created different access points into the text of the designed version. The heat maps for both passages support this by showing a much heavier focus on conventional top-down left to right reading patterns for participants who read the undesigned passage.

LIMITATIONS/SUGGESTIONS FOR FUTURE RESEARCH

Though this study provides evidence to support the idea that typographical cueing leads to increased memory and recall, it cannot be interpreted to mean that retention of ideas is enhanced. This study primarily focused on short-term recall.

Second, it is difficult to make conclusions about the impact of different typographical features – due to the fact that the study did not isolate for any particular typographical cues. Further work would need to be conducted to isolate specific typographical features.

Additionally, participants were all of a Japanese language background, therefore the results of this study could have limited applicability to a wider population. Furthermore, a larger sample size would perhaps yield more informative results.

CONCLUSION

Typography is deeply interconnected with many academic fields. The information provided by this study helps demonstrate this important connection and the potential benefits of design for second language acquisition and education. Simple design provides ways to enhance and make texts more suitable for achieving their intended purpose. All educators would benefit from considering the way how typography and design can positively enhance the amount of material noticed and processed by language learners. Typography is one way to effectually create “an increase in efficiency in how knowledge is communicated” (Lanham, 2006, p. 92).

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Appendix A

Undesigned Passage

Suprasegmentals

To improve English pronunciation, many researchers suggest that studying and practicing suprasegmental features.

What are suprasegmental features? Suprasegmentals are features that exist above or [outside] of the actual sounds of the language.

There are three main suprasegmental features: stress, intonation, and pausing.

Stress

Stress means a sound is longer and louder.

There are two types of stress, 1. lexical (word) and 2. sentence stress.

Intonation

Intonation refers to the rise and fall of the voice. In English, there are many different ways intonation is used. For example, when we ask a yes/no question, the intonation rises at the end of the question.

Pausing

Pausing is another important part of language. Pausing in the correct places can help listeners understand you better.

Three common pause locations are:

1. After a noun phrase.
2. Before a prepositional phrase.
3. At punctuation.

Appendix B

Designed Passage

Suprasegmentals

To improve English pronunciation, many researchers suggest studying and practicing **suprasegmental** features.

What are suprasegmental features?

Suprasegmentals are features that exist **above** or [outside] of the actual sounds of the language.

There are **3** main suprasegmental features:

Stress intonation ...pausing....

Stress

Stress means a sound is **longer** and **louder**.

There are **two** types of stress, ① lexical (*word*) and ② sentence stress.

Intonation

Intonation refers to the **rise** and **fall** of the voice.

In English, there are many different ways intonation is used.

For example, when we ask a **yes/no question**, the intonation **rises** at the end of the question.

Pausing

Pausing is another important part of language. Pausing in the correct places can **help** listeners *understand* you better.

Three common pause locations are:

- 1 After a **noun** phrase.
- 2 Before a **prepositional** phrase.
- 3 At *punctuation*.